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CONSTRUCTION OF THE EXPLORATORY STUDIES FACILITY AT YUCCA MOUNTAIN - NORTH RAMP

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ABSTRACT

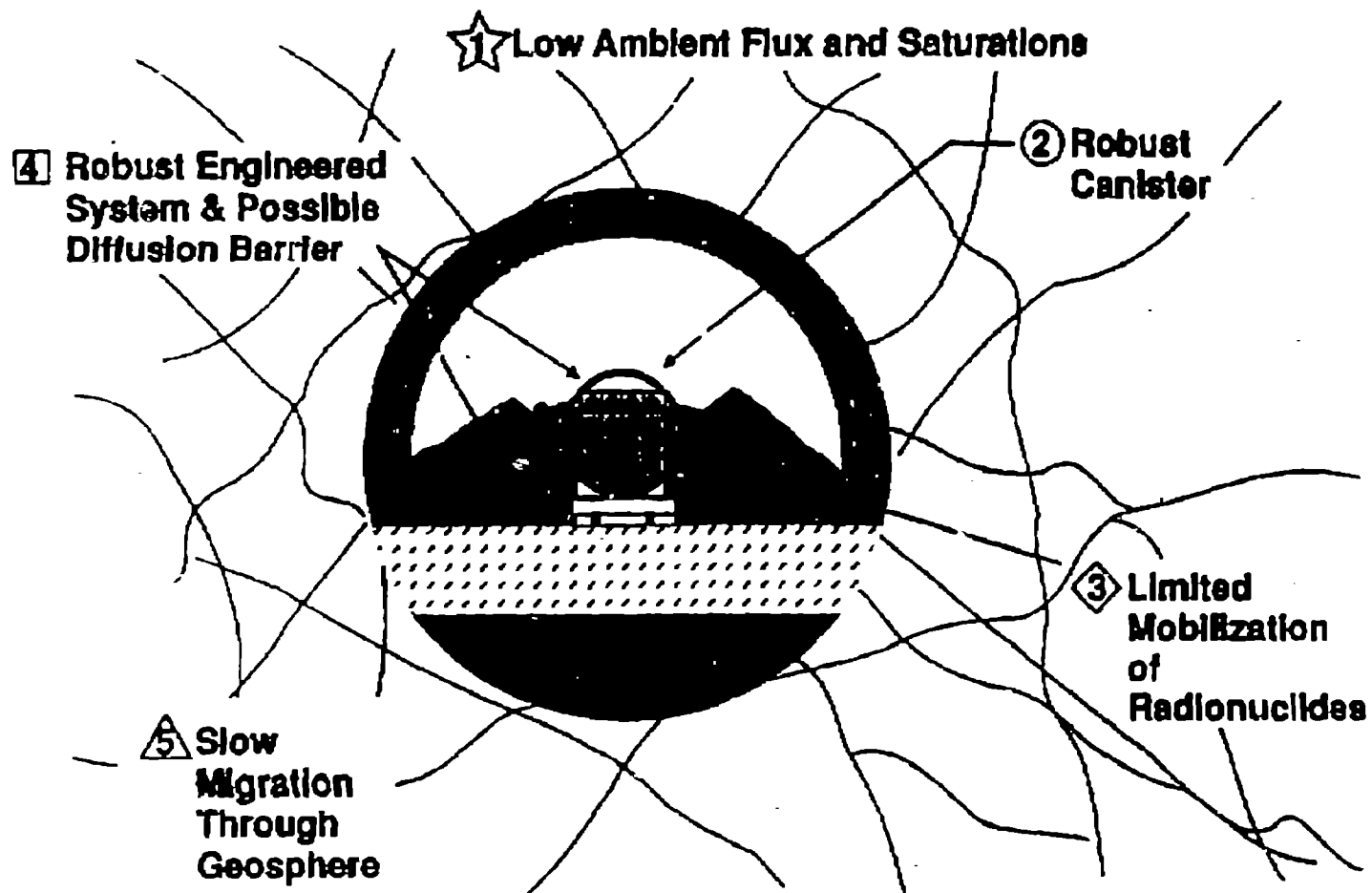
Yucca Mountain Site Characterization Office of the U.S. Department of Energy is constructing an Exploratory Studies Facility, approximately 160 km (100 miles) northwest of Las Vegas, Nevada. This facility will be used to gather geological, hydrological, geomechanical, thermomechanical, and geochemical information to characterize Yucca Mountain as a potential site to isolate High-Level Radioactive Waste from the accessible environment. The Exploratory Studies Facility, when completed shall consist of two ramps from the surface, a connecting drift, underground test areas and below ground operational support facilities. The ramps and connecting drift are being mined by a 7.62 m (25 ft) diameter Tunnel Boring Machine. This machine was fabricated for the Department of Energy by Construction Tunneling Services, Inc; of Kent, Washington.

This paper describes the current status of the construction of the North Ramp at Yucca Mountain. At the time of this writing, the North Ramp had advanced to a distance of about 517 m (1700 ft). With the exception of some minor problems through Bow Ridge fault, the excavation has progressed as expected.

INTRODUCTION

To characterize Yucca Mountain (YM), the U.S. Department of Energy's (DOE) Yucca Mountain Site Characterization Office (YMSCO) is constructing an Exploratory Studies Facility (ESF). The ESF is constructed to perform geological, geochemical, hydrologic, thermomechanical, and geomechanical tests to assess the suitability of YM to host High-Level Radioactive Waste (HLW) produced by commercial nuclear power plants and defense operations. It is required that the HLW be isolated from the accessible environment for 10,000 years¹. The barriers to control the release of radioactive materials will consist of natural barriers and engineered barriers such as waste containers and back fills (Figure 1). The information to assess the characteristics of the site is obtained by implementing a comprehensive, integrated, surface, underground, and laboratory based testing program. This paper describes the current status of the work being performed to construct the ESF.

Top-Level Strategy for Waste Containment and Isolation



EXPLORATORY STUDIES FACILITY

The ESF will consist of a North Ramp, South Ramp, a Main Drift that connects the two ramps, and a number of other exploratory and test drifts. Figure 2 shows the general layout of the ESF. Excavation was started from the North Ramp Portal. A horseshoe shape starter tunnel² for the tunnel Boring machine (TBM), approximately 9.14 m (30 ft) in diameter, 61 m (200 ft) long, was excavated by a controlled drill and blast method. The 7.62 m (25 ft) diameter TBM was procured, shipped to, and assembled at YM. TBM assembly started in April 1994, and the assembled TBM was moved to the face during August and September of 1994. A readiness review was performed prior to the start of TBM operations. For that review, TBM operations were divided in four phases: Phase 1 - start up testing; Phase - 2 operation of the TBM after the tail shield clears the starter tunnel; Phase - 3 operation of the TBM and the conduct of scientific investigations following installation of the mapping gantry; and Phase 4 - fully operational phase - after the muck conveyor has been installed. At present, the Project is in Phase 3. The muck is being removed by muck cars.

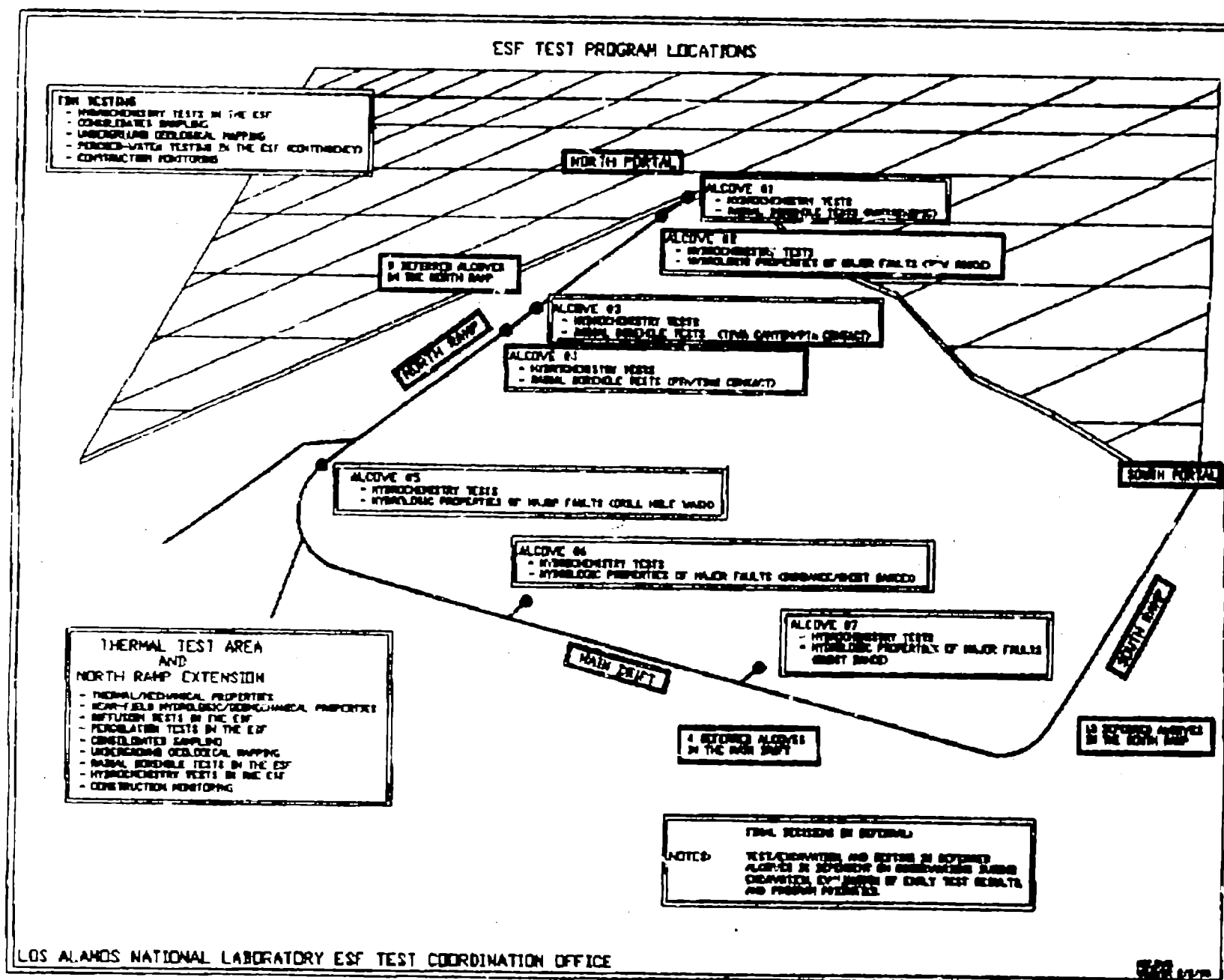
The TBM, procured for YM, was designed to operate in diverse geologic conditions. Unlike conventional tunneling operations, where the TBM generally stays within one rock type, the TBM at YM will cross multiple geologic units as it excavates from the surface to a depth of about 305 m (1000 ft). Key characteristics of the TBM are presented in Table 1.

As noted, the TBM has a full shield to provide ground support at all times as the excavation progresses. Some of the major differences, as compared to a conventional TBM, are: a robust hydraulic system to minimize leakage of fluids and a much longer trailing gear to accommodate a geologic mapping gantry. This TBM will be used to excavate the entire ESF loop as shown on Figure 2. Auxiliary mining, such as test alcoves, refuge chambers, shops etc., will be excavated using other mechanical equipment and/or drill-and-blast techniques as applicable. Technology to mine hard rocks mechanically is being explored and is under development within the YMSCO.

The North Ramp dips at a gradient of -2.1% to the West and is 2800 m (9190 ft) long. The North Ramp turns South at a gradient of + 0.5% to 2.6% in the main drift. This main drift will be 3155 m (10,350 ft) long. At this point the excavation turns East and the South Ramp will be excavated at a gradient of +0.6% to a total distance of 1835 m (6020 ft). The maximum overburden is approximately 300 m (1000 ft). The South Ramp daylights at the East side of YM. There may be two extension drifts, one at the bottom of the North Ramp (North Ramp extension) and one at the bottom of the South Ramp (South Ramp extension). These extensions and other test areas may be excavated using a small diameter TBM or machines such as roadheaders. The North Ramp extension is to be excavated at a grade of + 0.5 to - 2.3%. The South Ramp extension is to be excavated at a grade of - 0.6% to - 0.9%. Figure 2 shows tentative locations of test alcoves. These test alcoves will be excavated

Table 1. Key Characteristics of the TBM at Yucca Mountain

Size-Diameter:	7.62 m (25 ft)
Length-without trailing gear:	12.2 m (40 ft)
Length-with trailing gear:	150 m (460 ft)
Motors:	12 each, two speed, 186 kW (250 hp) each
Primary Voltage:	12,470 V, 3 phase 60 Hz
Hydraulics:	2 transformers 2200 KVA each Designed to have fewer hydraulic connections. Amount of hydraulic fluid reduced from 4542 l to 1515 l (1200 to 400 gallons). This reduces the potential of impact on the site by any spills/leaks.
Grippers:	Four grippers: 2 side, 1 top and 1 bottom. Gripper thrust maximum 27.5 megapascal (4000 psi) Gripper force of 1.65 megapascal (240 psi)
Stroke:	762 mm (30 inches)
Cutters:	48 discs at 43.18 cm (17 in) in diameter
Thrust:	1.63 million Kg (3.6 million lbs) 8 cylinders for maximum advance rate of 5.5 m/hr (18 ft/hr)
Shield:	Fully shielded machine
Dust Control/water:	None at the head. Water is used at the conveyor transfer points.
Turning Radius:	152.44 m (500 ft)
Steel Set Erector - Capacity:	8WF31 Wide Flange
Rock Support System:	Near Shield. Install Rock Bolts through shield. At the trailing gear Install permanent Rock Bolts. Bolts shall be super swellex, Williams etc.
Probe Drilling Probe:	Ability to Drill ahead of face
Muck Conveyor:	TBM 1066 mm (42 in) 960 m ³ /hr. at 122m/hr (400 ft pm)
Guidance System:	laser guided ZED
Other Unique Features:	Monitors flammable gas at the face. Uses Power Factor correction capacitor banks. Can operate on a slope of 12%. Provides capability to perform geologic mapping while the TBM is advancing.
Approximate Machine weight:	763,000 kg (1,720,000 lbs)
Present Mucking System:	Battery locomotive and four 16m ³ (21 yd ³) mine cars.



using either controlled drill-and-blast method, roadheaders, or other mechanical machines. Alcove #1 was constructed in 1994, using a controlled drill-and-blast method and is in use for testing purposes. Alcove #2, near the Bow Ridge Fault, will also be excavated by using controlled drill-and-blast method of excavation.

PREPARATION OF THE STARTER TUNNEL FOR TBM

The TBM components were shipped from Kent, Washington, starting in April 1994. Assembly of the TBM components were started by Kiewit/Parsons Brinckerhoff (Kiewit/PB) in April. All of the TBM components were on site by June 15, 1994. The TBM was fully assembled by August 15, 1994. While TBM assembly was in progress, the sidewall of the starter tunnel diameter near the face was reduced from about 9.14 m (30 ft) to 7.65 m (25.5 ft) by pouring a concrete cradle. The opening diameter was reduced to allow the TBM gripper pads on the walls and bottom gripper cradle on the invert grippers to engage the side walls and the floor. Construction for the pre-cast invert segments for the ramp was initiated in August 1994. Once the starter tunnel and the TBM were ready, the TBM was moved into the starter tunnel. It required one day to move the TBM into the starter tunnel and position it for Phase 1 activity.

SUPPORT SYSTEM

It was planned to support the initial TBM excavated portion of the ramp using steel sets. The rock conditions in the starter tunnel had proved to be quite poor² and contained a large number of lithophyses.

The starter tunnel ground support system primarily consisted of split sets, welded wire fabric, grouted rebar, threaded roof bolts, and fibercrete. Seven lattice girders were installed at the entrance of the starter tunnel to enhance the structural stability of the area near the portal. Large voids, along the ribs, were filled by placing fibercrete as necessary. Ground support in the TBM portion of the ramp consists of 183 steel sets on 1.22 m (4 ft) center and rock bolts with wire mesh.

TEST ALCOVE #2

The nominal alcove centerline for the test Alcove #2 is located at station 01+ (71.96 m [564 ft]). This alcove will be excavated using the controlled drill-and-blast method. This alcove will be used to characterize the hydrologic and geochemical environment of the Bow Ridge Fault. Lagging from the steel sets will be removed, if required, and a brow will be established to excavate the alcove, if required. The nominal dimensions of the alcove are: width 3.7 m (12 ft), height 3.7 m (12 ft), and depth of 40 m (131 ft). The end of the alcove should have width and height of 5 m (16.5 ft).

TESTING IN THE RAMP

The primary objective of the ESF is to provide space to conduct scientific investigations to ascertain the suitability of YN as a potential HLW repository. Tests are being performed to obtain geologic characteristics (geologic mapping), geomechanical response (deformation) of the rock mass, and response of the steel sets. Types of instruments installed consist of load cells, multipoint borehole extensometers, vibrating wire strain gauges, and convergence pins. Additionally, the excavation is geologically mapped.

The Los Alamos National Laboratory (LANL) Test Coordination Office (TCO) coordinates the testing performed in the ESF by all participants. The TCO is responsible for developing test planning packages and job packages for the implementation of testing/monitoring in the ESF. In the North Ramp, tests are being performed by the U.S. Geological Survey (USGS) and Sandia National Laboratories (SNL). Laboratory test samples have been collected for LANL and Lawrence Livermore National Laboratory (LLNL). Geological mapping is being performed by the U.S. Bureau of Reclamation (USBR) under USGS contract.

To monitor operational safety, SNL has installed load cells, multipoint borehole extensometers, strain gauges, and convergence pins. Material samples have been collected for laboratory analysis.

Geologic information gathered by USGS/USBR and rock mass response information gathered by SNL is being provided to the Architect & Engineer and Constructor as an aid in modifying ground support systems and operations.

CURRENT STATUS

The TBM has advanced through some very complex geology starting with high lithophysae rock formations, a fault with approximately 84 m (280 ft) vertical displacement, and very soft rock formations. The fault zone was about 2.5 m (8 ft) wide. The TBM has performed satisfactorily. It was planned from the very start that steel sets would be used through these formations. Geologic conditions are continuing to improve, and it is expected that ground support in the future will mostly consist of rock bolts and wire mesh.

The underground muck transportation system at present utilizes a 25 ton battery electric locomotive. Four muck cars 16 m³ (21 yd³) are hauled per trip. A conveyor system has been procured and it will replace the battery system, for muck haulage, by late August or early September 1995. The muck conveyor will be 914mm (36 in) wide, operate at 183 m/pm (600 ft/pm). The conveyor is designed to transport 572 tph and have a peak capacity of 972 tph. Tests are to be performed in the ESF to evaluate retention of diesel exhaust in the ramp. This test is to be performed to determine if diesels can

be used in the ESF without having any adverse impact on site performance with respect to isolation of HLW or on the tests performed to characterize the site. The current plans are to continue to use battery locomotives.

Surface facilities have expanded and most of the operations are now located at the portal area. A change house will be available for use by June or July of 1995.

Maximum advance, for a day, to date has been about 18 m (60 ft). The TBM is expected to eventually excavate at an average advance rate of approximately 105 m/week (350 ft/wk). The TBM is to daylight in 1996, after excavating approximately 7770 m (25,500 ft). As the excavation progresses and various geologic units are intercepted, tests will be conducted as identified by the principal investigators.

SUMMARY

A major milestone was reached in the national effort to find a suitable site to isolate HLW from the accessible environment by starting the construction of the ESF in 1993. The effort was accelerated in 1994 when TBM operations commenced. The performance of the TBM continues to improve as experience is gained in mining the rocks at YM. The YMSCO is poised to make major progress through 1995 and 1996 in characterizing YM in determining the technical suitability of the site.

ACKNOWLEDGEMENT

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REFERENCES

1. U.S. Environmental Protection Agency, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, 40 Code of Federal Regulations Part 191, September 1985.
2. Kalia, Hemendra N. and Replogle, James M; "Starter Tunnel at Yucca Mountain", Proceedings of April 18-21 Annual Institute of Shaft Drilling Technology Conference, Las Vegas, Nevada April 1994.

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Figure 1. High Level Radioactive Waste Isolation Multi Barrier
Concept

Figure 2. General Schematic of the ESF

Table 1. Key Characteristics of Yucca Mountain TBM